TEMPORAL CHANGES IN ASTRONAUTS' MUSCLE AND CARDIORESPIRATORY PHYSIOLOGY BEFORE, DURING, AND AFTER SPACEFLIGHT (CIPHER-SPACEPHYS)

PI:
Nicole Strock

Co-Investigators:
Brian Prejean
Karina Marshall-Goebel
Jason Norcross
Taylor Schlotman

Background

- Little is known regarding time-course changes in muscle and aerobic performance over short and long duration spaceflight.
- Exercise countermeasures are not fully protective and there are large variability in the changes in muscle and aerobic performance.
- Maximal aerobic capacity (VO_2pk), lower body muscle cross-sectional area (CSA) and strength decrease by about 10% -15% after short (~14 days) and long-duration (~6 months) spaceflight.
- As spaceflight progresses towards longer exploration missions, countermeasures will need to be optimized to protect crew health and performance across all organ systems for exploration missions up to 3 years in duration.

Purpose & Hypotheses

- **Purpose:** To quantify the decrements in physical performance capabilities and provide more detailed information on the physiological rational for “why” and “when” observed changes in performance occur.

- **Aims:**

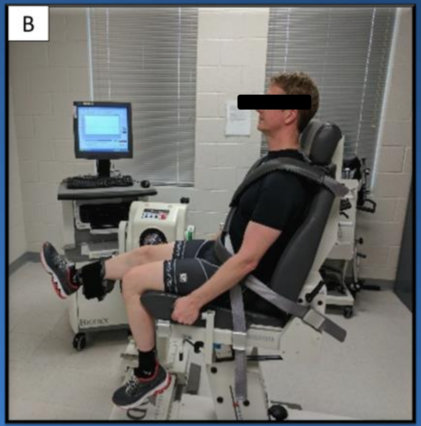
  1. Quantify time course of changes in physical performance including cardiorespiratory fitness and muscle mass, strength, and endurance pre-, in-, and post-spaceflight missions that are 2 months, 6 months, and 1 year in duration using standardized research and medical tests previously validated in 1g and microgravity.

  2. Quantify the individual variability in astronauts’ changes in the physical performance parameters (cardiorespiratory fitness, and muscle mass, strength, and endurance) pre-, in-, and post-flight in relation to exposure time to microgravity.

Methods

- Part of Complement of Integrated Protocols for Human Exploration Research (CIPHER)
- N=30 astronauts (n=10 for each mission duration of 2 months, 6 months, and 1 year)
- Strength and Aerobic Capacity Testing pre-, in-, and post-flight

Test	Data Share	Pre-flight	In-flight	Post-flight
Muscle Strength				
Isometric Mid-thigh Pull (Figure 1A)	-	L-90/30	FD14 (±7), R-14 (±7)	R+5 to R+7, R+30 (±3)
Isokinetic muscle strength (Figure 1B)	MEDB	L-270/180, L-90/30	-	R+5 (±1), R+14 (±1), R+30 (±2)
Aerobic Fitness				
VO_2pk test (Figure 1C)	MEDB	L-180, L-60	FD14, FD75, R-14	R+5 (±2), R+30 (±4)



Methods

- Data sharing for secondary outcomes pre-, in-, and post-flight
  - MEDB, Standard Measures, Egress Fitness, TBone2Study

Test.	Data Share	Pre-flight	In-flight	Post-flight
		Bone		
HR-PQCT	TBone2 Study	Pre- and Post-flight measures as indicated by TBone2 Study		
DXA BMD & Body Composition	MEDB	L-180/30	-	R+5/30
		Diet & Physical Activity		
Dietary and supplement intake	MEDB	L-90/30	Weekly or as clinically indicated by MEDB	R+0, R+20/30
Exercise/physical activity logs	MEDB	As indicated by MEDB		
Actigraphy	Standard Measures	-	Continuous or as indicated by Standard Measures	-
		Other		
Fitness & Performance Outcomes	Egress Fitness/MEDB	L-270/180, L-90/30	-	R+5/7, R+30
Sleep, Sensorimotor, Cognition	MEDB/ Standard Measures	L-90, L-30	Continuous or as indicated by MEDB and Standard Measures	R+0, R+1, R+2, R+30

Significance & Alignment

- This study will provide valuable information for describing why and when spaceflight-induced muscle and aerobic based adaptations occur over the course of spaceflight missions up to and beyond 1 year.

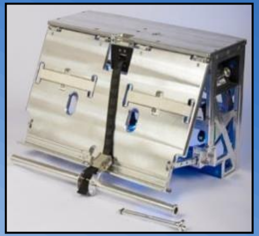
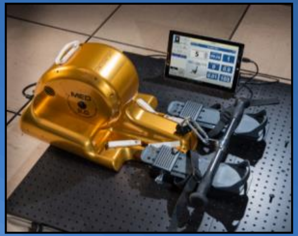
- Data can be used to inform the development of countermeasures and technologies for monitoring and mitigating crew health and performance risks during exploration class missions.

- This information will be vital in the assessment as to whether humans can be physically ready for deep space exploration such as Mars missions with current technology, or if additional mitigation strategies are necessary.

Significance & Alignment

- **Map to Human Research Roadmap.** A multi-system integrative approach that allows for rapid operationalization of research data on ISS is critical to inform exploration mission capabilities. Upon completion of this investigation, we will have addressed 5 NASA Human Research Program Integrated Research Plan risks and associated gaps that span cardiovascular, musculoskeletal, and sensorimotor physiological systems.

- **Alignment.** We have pre-coordinated with principal investigators (PI: Norcross), quantifying performance parameters related to EVA, sensorimotor adaptations in order to avoid test redundancy and propose tests and test dates that will inform multi-system responses and development of diverse and effective countermeasure technologies.

Current Status

- **Enrolled:** n = 1
  - Data collection anticipated to start early 2023
- **Interested:** n = 2
  - Pending signed consent
- Next Informed Consent Briefing scheduled in February

Questions?